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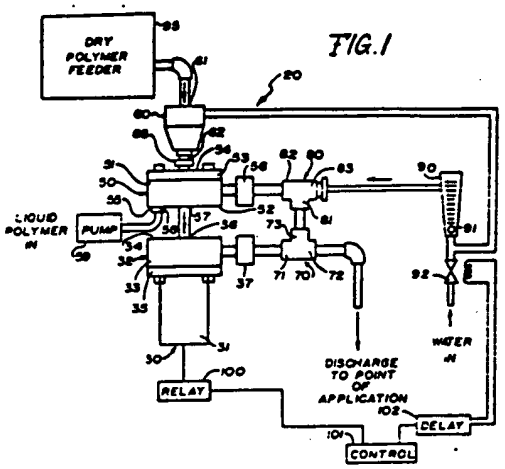
(54) Apparatus for mixing a dry or liquid substance and a liquid diluent.

(57) The mixing apparatus (20) includes a centrifugal pump (30) having a casing (32) and an impeller (40) located therein. The casing has a axially extending tubular inlet (36) located centrally on its end wall, the discharge being a tubular projection on the side wall's casing. A second casing (50) substantially identical to the casing of the pump, has a tubular projection on one of its end wall (52) coupled to the inlet of the first mentioned casing. Water is delivered to a tubular projection on the side wall (5l) of the second casing. Particulate polymer is delivered to the other end wall of the second casing. The swirling water in the second casing creates a lower pressure at its discharge to draw the polymer downwardly and into the first casing where it is vigorously mixed with the water.

FIG.1



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MIXING APPARATUS

Background of the Invention

The present invention relates to an apparatus for mixing a substance and a liquid diluent. The invention has particular application in the preparation of mixtures of a dry or liquid polyelectrolyte and water.

Polymers (used herein interchangeably with the term "polyelectrolyte") are commonly used in water treatment equipment in order to remove solids suspended in the water. Polymers carry an electrostatic charge which attracts particles suspended in water. Since virtually all solids carry a negative or positive charge, they are attracted to these polymers. Polymers have extremely large molecules with millions of charge sites that attract suspended particles. Synthetic polymers are available in dry and liquid form. Dry polymer is desirable for many applications because it has low weight, which saves on shipping expenses; can be easily stored and shipped in plastic lined sacks, which are relatively inexpensive as compared with disposable metal drums which must be used for liquid polymer, and has indefinite shelf life, whereas with liquid polymers the more dilute the mixture the shorter the shelf life. Furthermore, dry polymers have been approved as safe and effective in certain food grade and potable applications, whereas many liquid products have not received such approval. However, dry polymer must be mixed with water before it can be used. The dry polymer is hygroscopic and its suspensions in water are thixotropic. In other words, the dry polymers do not readily mix with water. Many existing mixing systems are subject to agglomeration of dry polymer particles during the wetting/dispersing step.

In certain instances, a liquid polymer is the choice. Liquid polymers may be either of the solution type or the emulsion type. It would be desirable to provide a mixing apparatus which can be readily converted to process liquid polymer.

Summary of the Invention

It is a general object of the present invention to provide a mixing system for mixing dry particulate material and a liquid diluent, which avoids the disadvantages of prior mixing systems while affording additional structural and operating advantages.

Another important object of the invention is the provision of a mixing apparatus of the type set forth, which is of relatively simple and economical construction.

Yet another object of the invention is the provision of mixing apparatus of the type set forth, which effectively prevents agglomeration of dry particulate material.

It is another object of the present invention to provide a mixing apparatus which can readily be modified to accommodate liquid polymer instead of dry polymer, and to switch between the two in an on-line configuration.

In summary, there is provided an apparatus for mixing a substance and a liquid diluent, the apparatus comprising: a centrifugal pump including a motor and a generally annular first casing and an impeller in the first casing rotated by the motor, the first casing having a discharge at the periphery thereof and an inlet generally centrally thereof, and a generally annular second casing having a substance inlet and a diluent inlet and a discharge, the diluent inlet being generally tangent to the casing, the discharge of the second casing being located generally centrally thereon, the substance inlet being adapted to be coupled to a source of the substance, the diluent inlet being adapted to a source of diluent, the discharge of the second casing being coupled to the inlet or the first casing.

In connection with the foregoing objects, it is another object of the invention to provide a mixing apparatus of the type set forth, which introduces all of the liquid diluent in an initial wetting stage.

The invention consists of certain novel features and a combination of parts hereinafter fully described, illustrated in the accompanying drawings, and particularly pointed out in the appended claims, it being understood that various changes in the details may be made without departing from the spirit, or sacrificing any of the advantages of the present invention.

Brief Description of the Drawings

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawings a preferred embodiment thereof, from an inspection of which, when considered in connection with the following description, the invention, its construction and operation, and many of its advantages should be readily understood and appreciated.

FIGURE 1 is a schematic view of a mixing apparatus incorporating the features of the present invention;

FIG. 2 is an enlarged view in vertical section of the funnel in the mixing apparatus;

FIG. 3 is a top plan view of the funnel;

FIG. 4 is a view in vertical section of the T-fitting of the mixing apparatus which receives the recirculat d polymer and the water;

FIG. 5 is a top plan view of the pump impeller casing of the mixing apparatus;

FIG. 6 is an elevational view of the casing;

FIG. 7 is an elevational view of the impeller;

FIG. 8 is a view in section taken along the line 8-8 of FIG. 7; and

FIG. 9 depicts a modification of the mixing system defined to process liquid polymer.

Detailed Description of the Preferred Embodiment

Turning now to the drawing and more particularly to Fig. I thereof, there is depicted a mixing apparatus 20 incorporating the features of the present invention. The mixing apparatus 20 includes a centrifugal pump 30 having a motor 3I and a casing 32 which contains an impeller 40 (FIGS. 7 and 8). The pump 30 has an inlet 36 and a discharge 37. In a particular embodiment, the pump 30 was made by Sta-Rite, produced .75 horse power and the impeller rotated at 3,450 RPM.

The apparatus 20 further comprises a second casing 50 which has construction very similar to the casing 32 but the casing 50 contains no impeller. The casing 50 includes a dry polymer inlet 54, a liquid polymer inlet 55, a water inlet 56, and a discharge 57. Preferably a check valve 58 is coupled to the liquid polymer inlet 55.

A funnel 60 is mounted to the casing 50. It includes a polymer inlet 6I and a discharge 62 coupled to the dry polymer inlet 54 of the casing 50 by means of a valve 68. The valve 68 can be replaced by a conduit if the pump 59 is not employed or a plug 96 (Figure 9) is employed.

The mixing apparatus 20 also comprises a T-fitting 70 having one leg 7I connected to the discharge 37, a second leg 72 constituting the main discharge of the mixing apparatus 20, and a third leg 73. A second T-fitting 80 has a first leg 8I connected to the leg 73, a second leg 82 connected to the water inlet 56 and a third leg 83. The leg 83 is coupled to a flowmeter 90. A constant flow valve may be employed in place of the flowmeter 90. A source of water is coupled to a solenoid valve 92 the outlet of which is connected to the flowmeter 90. In the absence of electrical power, the valve 92 is automatically closed. The flowmeter 90 has a control knob 9I to enable selection of the rate of water flow.

In operation, dry particulate polymer is delivered to a feeder 95 which transports the polymer to a point where it drops into the funnel 60 which guides the polymer into th casing 50. Water is delivered to the casing 50 tangentially so it swirls therein creating a region of lower pressur adjacent to the discharge 57 drawing the polymer and water downwardly and into the casing 32 wherein the impeller 40 vigorously mixes the two. The polymer at the discharge 37 is a thoroughly wetted and homogenous slurry. The liquid polymer is extended to the leg 72 from which it is taken for use in treating water or the like. Because of the dynamics of the apparatus 20, the polymer does not pass through the recirculation path defined by the leg 73 of the T-fitting 70 and the leg 8I of the T-fitting 80.

Liquid polymer is pumped into the casing 50 by means of a pulsating-type pump 59, such as one made by Liquid Metronics, Incorporated of Acton, Mass. When the apparatus is used to deliver dry polymer, the pump 59 is de-energized. When the apparatus 20 is used to dilute liquid polymer, the valve 68 is closed and the pump 59 is enabled. The check valve 58 prevents the contents of the casing 50 from exiting at the inlet 55. The polymer mixes with the water by the action of the impeller 40, in much the same manner as the dry polymer. However, because the system is basically clos d, a portion of the diluted polymer at the discharg 37 will be recirculated by passing through the legs 73 and 8I back to the water inlet 56. This recirculated portion will be further diluted and mixed along with fresh polymer and water. When the water is turned off, the liquid continues to recirculate. Thus, residence time is controlled by the water flow rate. The apparatus 20 can be quickly modified to proc ss dry or liquid polymer as required. The apparatus can be readily switched back and forth, on line.

Referring to FIGS. 5 and 6, the casing 52 is defined by a generally annular side wall 33, an end wall 34 and a flange 35 (FIG. I) which is attached to the housing of the motor 3I. The inlet 36 is an axially extending, tubular projection on the end wall 34 located generally centrally thereon. The discharge 37 is a tubular projection on the side wall 33 and disposed generally tangent thereto. The casing 32 has three ports 38 (two are shown) any one or more of which may be closed. The others can be used to be coupled-to-receive liquids.

As can be seen in FIGS. 7 and 8, the impeller 40 has spiral vanes 4I separated by spiral spac s 42. The impeller 40 is threaded to the motor shaft (not shown).

The polymer and water passing into the casing 32 at the center thereof are vigorously mixed as they pass through the rotating impeller and enter the turbulent zone at the inside surface of the sid wall 33 and exit tangentially through the discharg 37.

Ref rring back to FIG. I, the casing 50 is identical to the casing 32, but is inverted in orientation. The casing 50 has a generally annular side wall 5I and an end wall 52 integral therewith. The end wall

52 carries centrally th reon an axially xtending, tubular projection defining the discharg 57. Th inl t 55 is preferably located in the end wall 52 near the periphery thereof. Preferably the cover 53 is transparent so that one can see the interior of the casing 53 and what is transpiring therein. A tubular projection extends from the side wall 50 generally tangent thereto and defines the inlet 56 of the casing 50. A nipple is threaded into the projections on the two casings to interconnect the discharge 57 and the inlet 36. The check valve 58 is coupled to one of the ports in the wall 52 (like the ports 38). Other liquids, such as surfactants, may be applied to the other ports to enable several liquids to be simultaneously applied.

Water is introduced into the interior of the casing 50 through the inlet 56 and because it is introduced tangentially, the water swirls around and creates a zone of lower pressure adjacent to the discharge 57, tending to draw down downwardly the particulate polymer introduced to the inlet 54. This action helps to cause more thorough mixing action and a more homogeneous product.

Referring to FIGS. 2 and 3, the funnel 60 has a polymer inlet 6l and a discharge 62, the latter being defined by a smaller diameter throat 63 and a larger mouth 64. The interior of the funnel 60 in the region of the polymer inlet 6l has a cylindrical surface 65. A conical surface 66 extends from the surface 65 to the discharge 62. A water inlet 67 in the surface 65 is generally tangential thereto, so that water introduced into such inlet will swirl about the surface 65 and then downwardly along the surface 66, tending to wash such surfaces and maintain them free of the particulate polymer which is introduced through the inlet 6l. This operation tends to prevent the polymer from agglomerating in the funnel 60 and prewets the polymer to facilitate further wetting in subsequent stages. In an operative form of the invention, the inlet 6l was round having a two-inch diameter and the mouth 63 was round having a .75-inch diameter. This structure tends to minimize so-called "back wicking", that is the tendency to wet the dry polymer upstream and cause it to clump or agglomerate.

Referring to FIG. 4, the T-fitting 80 has an inner conduit 84 coaxial with the legs 82 and 83. A bushing 85 blocks the space between the leg 83 and the conduit 84. Water is introduced through the bore in the bushing 85 through the conduit 84 and into the water inlet 56. When the funnel 60 is replaced by the plug 96 in order to feed liquid polymer, a portion of the polymer from the discharge 37 passes through the leg 8l and into the leg 82. The recirculating polymer and the water are simultaneously introduc d into the casing 50 where they together swirl downwardly toward the discharge 56. The conduit 84 decreases the pressure difference between the water and the recircula- polymer so that the water pressure is not dir "fighting" the pressure of the recirculating polymer in part created by the centrifugal pump 30.

AC power for the pump motor 32 is supplied via a relay l00, the winding of which is coupled to one output of a control circuit l0l. When it is desired to energize the motor 3l, the control circuit l0l is caused to produce a signal which energizes the winding of the relay l00 causing its contacts to close. A second output of the control circuit l0l is coupled by way of a delay circuit l02 to the winding of the solenoid valve 92. The control circuit generates an output that energizes such winding to cause the valve to close and therefore permit water to be introduced.

When the apparatus 20 is idle, the casing 50 is flooded. It has been determined that when the pump motor 3l and the solenoid valve 92 are simultaneously energized, the water delivered to the casing is caused to splash into the funnel 60 and out the inlet 6l. But, if the pump motor 3l is energized just prior to the introduction of water, such splashing does not occur. In experimentation, it has been found that the pump motor 3l should be energized about one second prior to delivering water to the casing 50. Thus, the delay circuit l02 provides a delay of about one second. On the oth r hand, the delay cannot be too long because in the casings 32 and 50 would be vacuated completely. When it is desired to turn on the mixing apparatus 20, the control circuit l0l provides electrical signals on its outputs on e of which substantially immediately energizes the r lay l00 to cause the pump motor 3l to immediately become energized and the other of which causes n r- gization of the solenoid valve 92 about one second later by virtue of the delay circuit l02.

The same kind of phenomonon tends to occur when the apparatus 20 is turned off. In other words, if both the pump motor 3l and water are turned off at the same time, the splashing tends to occur. A reverse delay is incorporated for this purpose. The relay l00 incorporates a so-called "off" delay (not shown) and the delay circuit l02 is basically bypassed. Thus, when it is desired to turn off the apparatus 20, the electrical signals developed by the control circuit l0l are terminated. Th valve 92 is immediately closed and water to the funnel 60 immediately interrupted. After the delay period has passed, the relay l00 opens and the pump motor 3l is deenergized. The preferred "off" delay is also on the order of about one second.

It should be quite clear that there ar many ways to accomplish the operation just describ d. The relay l00 does not include any "on" dela ut does include one second of "off" delay. A se e delay circuit could be used instead. By the same

token, the "on" delay furnished by the delay circuit 102 could be provided directly in a solenoid valve 92. Or, both delays could be incorporated directly into the control circuit 101. Depending upon the overall system in which the apparatus 20 is used, the control circuit 101 could simply be a switch mechanism of some kind.

An alternative embodiment is depicted in FIG. 9. Instead of using a valve 63, the funnel can be removed and replaced with a plug 96, when liquid polymer is to be processed.

What has been described therefore is an improved mixing apparatus designed to create a liquid polymer from a dry particulate polymer, the liquid polymer effluent being thoroughly wetted and highly homogeneous. The mixing apparatus also has means to accept a liquid polymer instead of the dry polymer, which liquid polymer is diluted with water.

Claims

1. Apparatus (20) for mixing a substance and a liquid diluent, said apparatus comprising: a centrifugal pump (30) including a motor (31) and a generally annular first casing (32) and an impeller (40) in said first casing rotated by said motor, said first casing having a discharge (37) at the periphery thereof and an inlet (36) generally centrally thereof, and a generally annular second casing (50) having a substance inlet (55) and a diluent inlet (56) and a discharge (57), said diluent inlet being generally tangent to said casing, the discharge of said second casing being located generally centrally thereon, said substance inlet being adapted to be coupled to a source of the substance, said diluent inlet being adapted to be coupled to a source of diluent, the discharge of said second casing being coupled to the inlet of said first casing.

2. Apparatus (20) for mixing a substance and a liquid diluent, said apparatus comprising: a centrifugal pump (30) including a motor (31) and a generally annular first casing (32) and an impeller (40) in said first casing rotated by said motor, said first casing having a discharge (37) at the periphery thereof and an inlet (36) generally centrally thereof, and a second casing (50) having a generally annular side wall (51) and first (53) and second (52) end walls respectively at the ends of said side wall, said second casing having a substance inlet (54) and a diluent inlet (56) and a discharge (57), said diluent inlet being generally tangent to said side wall, said substance inlet (54) being in said first end wall (53) generally centrally thereon, the discharge (57) of said s cond casing being in said second wall (52) generally centrally th reon, thereby to create a swirling flow of diluent in said second casing and a region of lower pressure in the region of the discharge thereof to draw the particulate material from said particulate inlet to the discharge of said second casing, said particulate inlet being adapted to be coupled to a source of dry particulate material, said diluent inlet being adapted to be coupled to a source of diluent, the discharge of said second casing being coupled to the inlet of said first casing.

3. The mixing apparatus of claim 2, wherein the substance is dry particulate material and the liquid diluent is water, and further comprising a funnel (60) coupled to said substance inlet (54) for receiving the dry particulate material and directing it to said substance inlet.

4. The mixing apparatus of claim 2, and further comprising a flowmeter (90) coupled between the source of diluent and the diluent inlet (56).

5. The mixing apparatus of claim 3, wherein said second casing has a liquid polymer inlet (55), and a check valve (58) coupled to said liquid polymer inlet and being adapted to be coupled to a source of liquid polymer.

6. The mixing apparatus of claim 5, wherein said liquid polymer inlet (55) is in said second end wall (52), and further comprising means (96) for blocking said dry polymer inlet.

7. The mixing apparatus of claim 5, and furth r comprising valve means (68) coupling the dry particulate polymer to the substance inlet (54).

8. The mixing apparatus of claim 5, wherein the discharge (37) of said first casing (32) is coupled to the diluent inlet (56) of said second casing (50).

9. The mixing apparatus of claim 2, wherein the discharge (37) of said first casing (32) is a tubular projection on the side wall (33) thereof and substantially tangent thereto, the inlet (36) of said first casing being axially extending tubular projection on said end wall (34) thereof, and the diluent inlet (56) of said second casing (50) is a tubular extension on said side wall (51) and tangent thereto, the discharge (57) of said second casing being an axially extending tubular projection on said second end wall (52).

10. The mixing apparatus of claim 3, wherein said funnel (60) has a cylindrical interior surface (65) near said inlet and a frustoconical interior surface (66) between said cylindrical surface and the discharge (62) of said funnel.

11. The mixing apparatus of claim 2, and further comprising valve means (92) coupled to said diluent inlet (56), said valve means being adapted to be coupled to a source of diluent, the discharge (57) of said second casing (50) being coupled to the inlet (36) of said first casing, switch means (100) for coupling a source of power to said centrifugal pump, and control means (101) for operating

said switch means and said valve means for selective opening and closing thereof, the mechanism defined by said switch means and said valve means and said control means including delay means (100-102) to cause said switch means to automatically close before said valve means by a predetermined amount of first delay.

12. The mixing apparatus of claim 11, wherein the mechanism defined by said relay means and said valve means and said control means includes delay means (100-102) to cause said switch means to automatically open after said valve means is opened by a predetermined amount of second delay.

13. The mixing apparatus of claim 11, wherein said delay means is incorporated into said switch means.

14. The mixing apparatus of claim 11, wherein said delay means comprises a delay device (102) coupled between said control means and said valve means to cause said switch means to automatically open after said valve means is opened.

15. Apparatus (20) for mixing a liquid polymer with a liquid diluent, said apparatus comprising: a centrifugal pump (30) including a motor (31) and a generally annular first casing (32) and an impeller (40) in said first casing rotated by said motor, said first casing having a discharge (37) at the periphery thereof and an inlet (36) generally centrally thereof, a second casing (50) having a generally annular side wall (51) and first (52) and second (53) end walls respectively at the ends of said side wall, said second casing having a polymer inlet (55) and a diluent inlet (56) and a discharge (57), said diluent inlet being generally tangent to said side wall (51), said polymer inlet (58) being in said first end wall (52) generally centrally thereon, the discharge (57) of said second casing being in said second wall generally centrally thereon, a pump (59) coupled to said polymer inlet (58), said pump being adapted to be coupled to a source of liquid polymer, said diluent inlet being adapted to be coupled to a source of diluent, the discharge (57) of said second casing being coupled to the inlet (36) of said first casing.

16. The mixing apparatus of claim 15, and further comprising means (80) for preventing the liquid diluent from being coupled to said discharge (37) of said first casing.

17. The mixing apparatus of claim 15, and further comprising an outer conduit (82) coupled to said diluent inlet (56), means (81) coupling said discharge (37) of said first casing to said outer conduit, an inner conduit (84) in said outer conduit (82) and coupled between a source of water and said diluent inlet (56).

FIG. 1

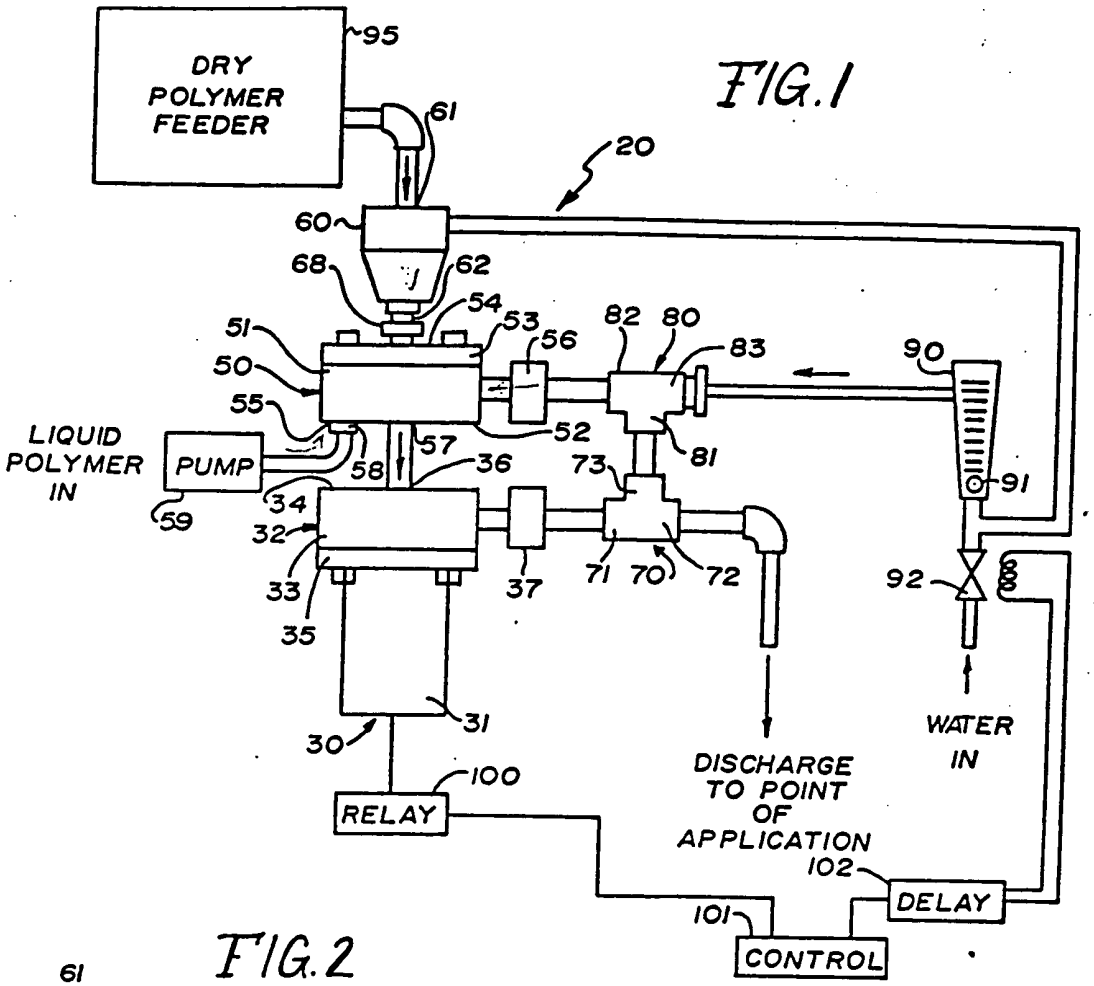


FIG. 2

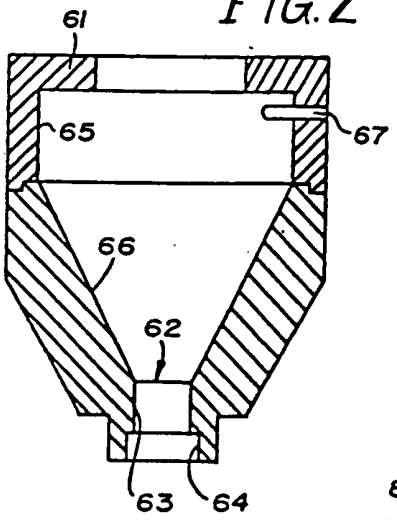


FIG. 3

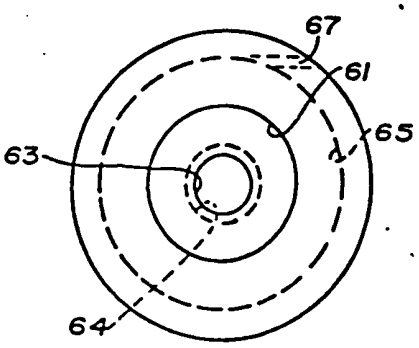
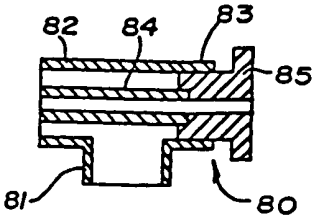


FIG. 4



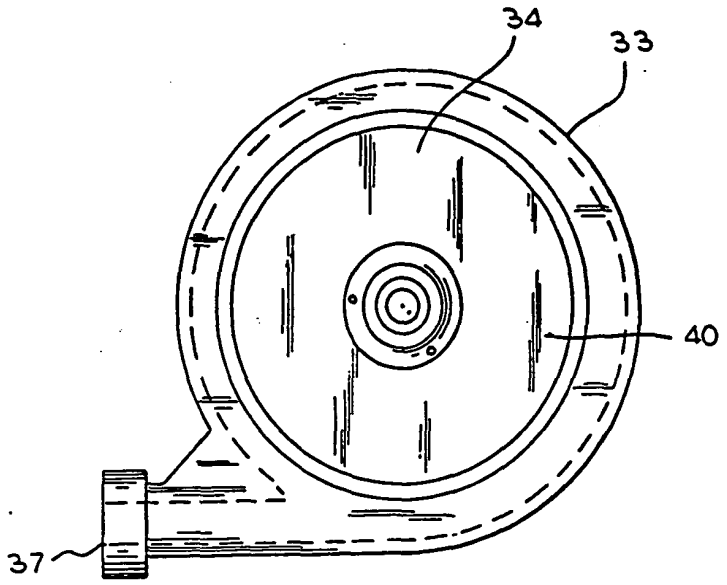


FIG.5

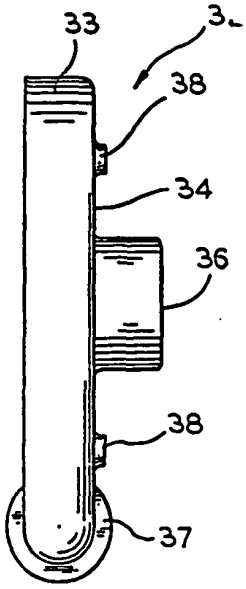


FIG.6

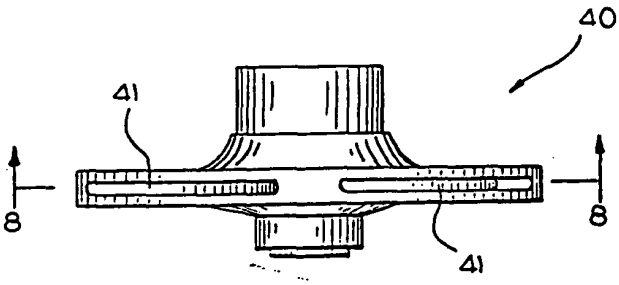


FIG.7

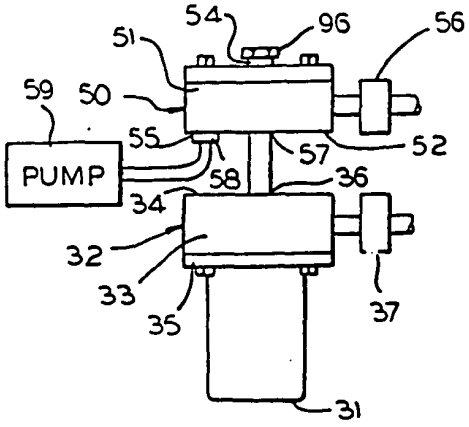


FIG.9

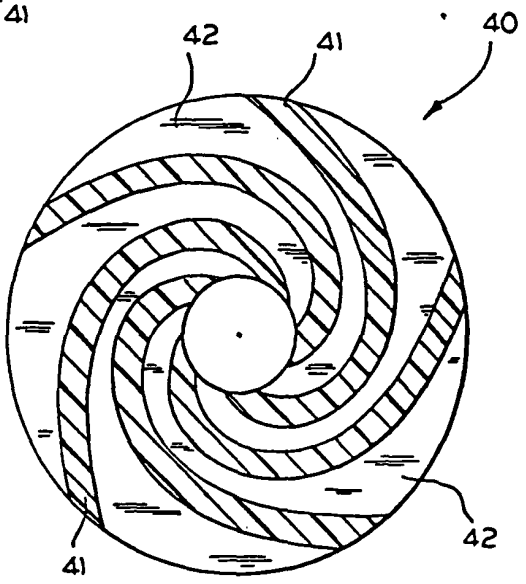


FIG.8